

### Technical Attachment

## **GPS-Derived Integrated Precipitable Water Estimates: A Collaborative Success Story**

### Scientific Services Division

Real-time estimates of Integrated Precipitable Water (IPW) are now available for several sites in Florida, and the number of locations will be increasing, thanks to the collaborative efforts over the past few years on the part of Florida NWS offices and other NOAA and Florida state agencies. The IPW estimates come about because signals from GPS satellites are affected by atmospheric water vapor. For some time NOAA's Forecast Systems Laboratory (FSL) has been driving IPW estimates from surface based GPS sensors. The sensors are generally "targets of opportunity," which are operated by various agencies who make the data available to FSL without cost. FSL then provides the derived data for use by forecasters and others via an interactive GPS meteorology Web site <http://www.gpsmet.noaa.gov/jsp/displays/display.jsp>

The process continues to be enhanced by FSL, but the IPW estimates are based on a complicated algorithm which involves integration of the GPS time differential from the two frequency channels, using high resolution satellite positions and surface observations of pressure and temperature. The estimates, which can be derived as frequently as about every half-hour, have been shown to verify closely with the twice-daily observations of precipitable water derived from balloon (RAOB) observations.

The growing number of Florida GPS sites results from a program by the Florida Department of Transportation (DOT) to install 50 dual-frequency master stations around the state over the next couple of years. The installations will provide the state with precise geophysical observations for mapping and other purposes. Several sites have been installed so far, and two are at NWS facilities (Tallahassee and Jacksonville) where the NWS provides for minimal power requirements as well as a safe site for locating the \$50,000 equipment. The NWS became involved when Pat Welsh, the WFO Jacksonville Science and Operations Officer, was made aware of the DOT program by Ronnie Taylor, a mapping, geodesy and GIS specialist with the National Ocean Service. Ronnie is NOAA's liaison with the Florida Department of Environmental Protection - *for the purpose of* fostering interagency cooperation in the area of GIS applications. Knowing of FSL's work, Ronnie also suggested the potential for applying IPW derivations to forecast operations.

Following up on the suggestion, Pat learned that Seth Gutman and his team at FSL were already computing IPW from GPS sites at Cape Canaveral and in the Florida Keys. A meeting was arranged (at Embry Riddle Aeronautical University) involving Pat, Seth, other Florida SOOs, Ronnie Taylor and the Florida DOT. At this meeting of three NOAA agencies (NWS, NOS, and OAR [FSL]), the state of Florida (DOT), and university participants, the potential value of IPW estimates to the NWS was validated *as well as* the benefits to the DOT to be derived from a more accurate GPS data set as a result of applying moisture correction to the data. A plan was worked out whereby FSL would compute IPW from the new GPS locations and add the data to its growing Web site (Fig. 1).

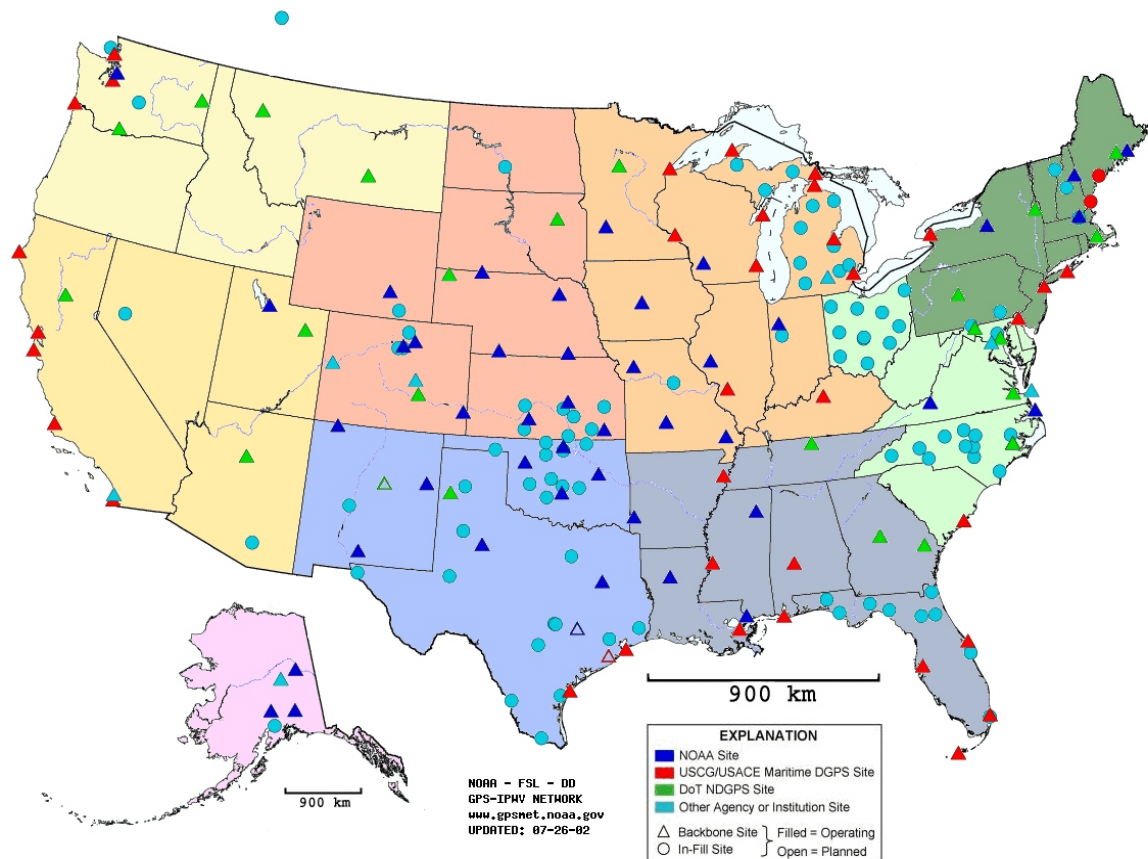


Figure 1. NOAA Forecast Systems Lab GPS-IPW Network (updated July 26, 2002).

Precipitable water estimates from the first four DOT sites - at Jacksonville, Palatka, Panama City and Defuniak Springs - recently became available, and the results are very impressive for several reasons. Figure 2 below shows a comparison of GPS-based IPW estimates with upper air (RAOB) observations at Jacksonville. Note the close agreement between RAOB and GPS-derived measurements, as well as the additional structure (long suspected by forecasters) detected by the higher time-resolution GPS observations as the precipitable water varies during the course of the day. The density of GPS locations is considerably greater than upper-air sites, and the GPS-derivations also reveal significant spatial variations that are not detected by the spacing of RAOB observations. The Florida forecasters closely monitor the morning RAOB sounding for changes in precipitable water, which provides important clues to moisture convergence and the timing and location of afternoon convection. Until the GPS soundings became available changes in precipitable water during the day could only be inferred or based on model forecasts. The IPW estimates derived by FSL now provide forecasters with a new analysis and forecasting tool.

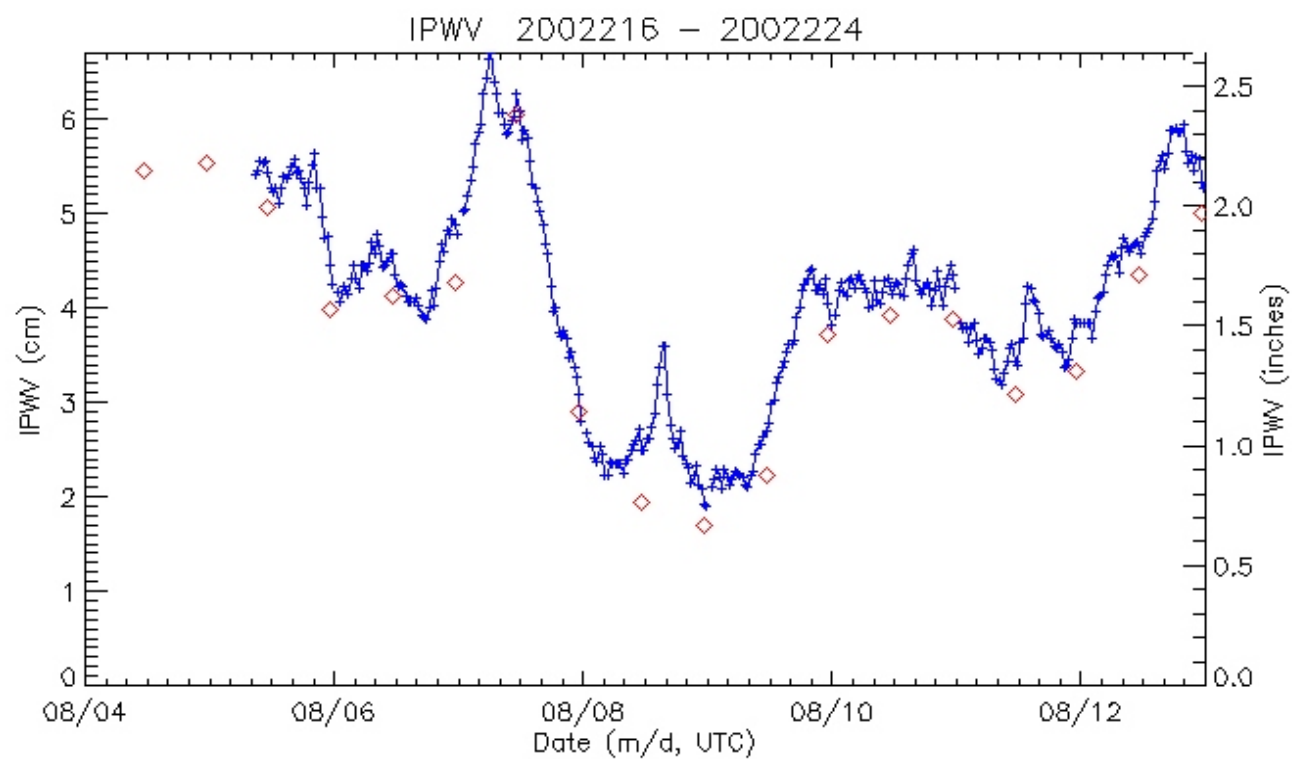


Figure 2. GPS-derived Integrated Precipitable Water estimates for Jacksonville, Florida. Triangles indicate precipitable water values derived from twice-daily RAOB observations.